

Double-Crested Cormorant Impacts on Sport Fish: Literature Review, Agency Survey, and Strategies

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Abstract: In response to concerns expressed by anglers, the U.S. Fish and Wildlife Service conducted an extensive review of published studies done throughout the United States and Canada on the impacts of double-crested cormorants (*Phalacrocorax auritus*) on sport-fish populations in open waters. The literature review indicated that fish species valued by sport and commercial anglers make up a very small proportion of the cormorants' diet and that these birds have a minor effect on fish populations compared to the effects of sport and commercial fishing, natural predation, and other mortality factors. The Service sent a questionnaire to State agencies, soliciting their biological information and

professional opinions on the role of cormorants in regulating wild fish populations, affecting sport angler catch, and causing adverse impacts on tourism and other fish-related economies. Agency attitudes toward cormorant population control were also assessed. On the basis of literature review and the survey responses, it does not appear that a strategy of reducing double-crested cormorant populations to benefit sport fish is biologically warranted at this time.

Keywords: double-crested cormorant, *Phalacrocorax auritus*, food habits, impacts, population control, sport fish, U.S. Fish and Wildlife Service

The double-crested cormorant (DCCO) has been maligned for most of this century by major segments of society, especially sport and commercial anglers, who have viewed it as a direct competitor for valuable fish resources. Human conflicts with DCCO's have increased exponentially in the 1980's and 1990's as DCCO populations have responded to a favorable array of human-caused changes in environmental conditions that have enhanced recruitment and survivorship or simply increased the availability of suitable prey (Weseloh and Collier 1996).

As a result of remarkably similar patterns of growth in DCCO populations and the aquaculture (especially catfish, *Ictalurus punctatus*) industry beginning in the late 1970's, conflicts became evident in the late 1980's and intensified during the 1990's (Nettleship and Duffy 1995).

More recently (beginning about 1992), the U.S. Fish and Wildlife Service (FWS) started to receive complaints from sport anglers that DCCO's were having negative impacts on sport fish populations. Although largely anecdotal and therefore difficult to evaluate, complaints were received from across the country about many species (e.g., largemouth bass [*Micropterus salmoides*] and crappies [*Pomoxis* spp.] in Arkansas and Texas, fingerling trout and salmon in eastern Lake Ontario, yellow perch [*Perca flavescens*] and walleye [*Stizostedion vitreum*] in the Great Lakes, and trout in the far West). The geographic extent of

the complaints suggested that there was at least a growing perception among sport anglers that the DCCO was having a negative impact on their fishing opportunities. Additionally, charter boat operators and resort owners have complained of economic impacts, thereby sparking the interest of politicians.

The objectives of this paper are threefold: (1) to briefly review the literature on DCCO food habits in freshwater habitats, (2) to provide a summary of how State agencies and the FWS view the DCCO-sport fish conflict, and (3) to briefly outline guidelines for dealing with conflicts between DCCO's and humans (including, but not limited to, sport anglers).

Methods

Literature Review

Our review of the available literature located 25 "major" studies conducted in 13 States and Provinces, 1923–94, that reported results based on a minimum of 30 samples (e.g., regurgitations, pellets, or individual food items; see Hall 1926, Munro 1927, Lewis 1929, Baillie 1947, Trautman 1951, McLeod and Bondar 1953, Vermeer 1969, O'Meara et al. 1982, Ludwig 1984, Gallant 1986 unpubl., Craven and Lev 1987, Haws 1987 unpubl., Hobson et al. 1989, Ludwig et al. 1989, Neumann 1992 unpubl., Campo et al. 1993, Karwowski 1994 unpubl., MacNeil 1994 unpubl.).

Survey of State Agencies

In August 1996, a letter was sent to the directors of all 50 State fish and wildlife agencies. The letter solicited their insight on the severity of the DCCO–sport fish conflict in their respective States and their suggestions for resolving this controversy in a suitable manner. Enclosed with the letter was a list of 10 questions to help focus their thoughts and to suggest the types of information that would be most useful to the Service.

States were not required to respond to all of the questions, and many chose not to do so. Also, rather than directly addressing each of the questions, some States responded in a narrative style. In such instances, we tried to collate each opinion expressed with the most pertinent question. We made every effort to reflect the perspectives presented by the individual States accurately.

Results

Literature Review

What Did We Learn From This Synthesis?—At least 75 species of fish representing 22 families were detected as prey items, but only 29 species ever comprised more than 10 percent of the DCCO diet at a specific site. These results confirm that the DCCO is an opportunistic piscivore, feeding on a wide diversity of prey. In a given situation, it tends to prey on those species that are most abundant and most easily captured. The ease with which a fish can be caught depends on a number of factors, including distribution (vertical and horizontal), habitat (open water v. vegetated zones), relative abundance, behavior, and physical condition of the fish. Thus, the composition of the DCCO's diet varies considerably from site to site, depending on the fish species that are most readily available.

Eighteen species were detected at five or more sites, but only five species (alewife [*Alosa pseudoharengus*], brook stickleback [*Culaea inconstans*], ninespine stickleback [*Pungitius pungitius*], yellow perch, and slimy sculpin [*Cottus cognatus*]) consistently comprised more than 10 percent of the diet. Of these, only the yellow perch is regularly sought by sport anglers. The consistency of yellow perch in the diet probably reflects its widespread distribution and abundance rather than a preference.

On average, prey species represented major (i.e., more than 10 percent) components of the diet in 29 percent (74) of the 252 instances in which they were detected (table 1). The frequency with which three families of fish occurred as major components of the diet differed significantly ($P \leq 0.05$, χ^2) from the expected value of 29 percent: herrings (alewives and shad [*Dorosoma* spp.], specifically) and sticklebacks occurred as major prey items more than twice as frequently as expected (75 percent and 70 percent, respectively), whereas salmonids (trout, salmon, and allies) were represented in the diet as major prey items only half as frequently as expected (15 percent) (table 1). Members of all other families (including sunfish and perches) occurred as major and minor components of the diet in about the proportions expected.

What Didn't We Learn From This Synthesis?—The collective studies revealed little about food preferences of DCCO's. That would require simultaneous information about the relative abundance of all potential prey species at a given site, but such information is universally lacking in these studies.

Similarly, the collective studies revealed little about the impacts of DCCO's on fish populations. That would require quantitative information about the numerical abundance of the prey species and detailed knowledge of the effects of all other factors (both biotic and abiotic) that can affect fish populations.

Table 1. Comparison of observed and expected distribution of instances in which members of various fish families were found to be minor (< 10 percent) or major (> 10 percent) components in diet of DCCO's¹

Distribution as minor or major components of diet							
		Minor (< 10%)		Major (> 10%)			
Family	<i>n</i>	Obs ²	Exp ²	Obs	Exp	χ^2	<i>P</i>
Herrings	12	4	8.5	8	3.5	7.59	³ <0.01
Trouts	27	23	19.1	4	7.9	4.46	⁴ <.05
Minnows	29	20	20.5	9	8.5	0.04	>.75
Suckers	11	8	7.8	3	3.2	0.02	.90
Bullheads, catfish	18	14	12.7	4	5.3	0.45	.50
Sticklebacks	10	3	7.1	7	2.9	8.00	³ <.01
Sunfish	48	37	33.9	11	14.1	1.13	>.25
Perches	28	18	19.8	10	8.2	0.50	>.25
Sculpins	11	6	7.8	5	3.2	1.19	>.25
13 Other families	58	45	41.0	13	17.0	1.59	>.10
Totals	252	178	—	74	—	24.9	⁵ <.01

¹ Samples were collected at 25 sites in 13 States and Provinces. See Methods section for references.

² Obs = observed, Exp = expected.

³ The proportion of studies in which fish of this family were major components of the diet was significantly greater than expected (2 (10 contingency test).

⁴ The proportion of studies in which fish of this family were major components of the diet was significantly less than expected (2 (10 contingency test).

⁵ The frequency with which fish of different families were major components of the diet differed significantly from a uniform distribution (2 (10 contingency test).

Subsequent to this synthesis, several studies (Blackwell et al. 1995, Ross and Johnson 1995, Fowle et al. in review) have reported potentially severe localized predation on sport fish populations by DCCO's. These were usually situations in which a fishery had been intensively managed to benefit sport anglers. Similar findings have been reported from Europe (Russell et al. 1996) for the closely related great cormorant (*P. carbo*).

Survey of State Agencies

Responses were received from 25 State agencies distributed within geographic regions as follows: Northeast (Connecticut, Maine, New Hampshire, New York, Pennsylvania, Vermont), Southeast (Alabama, Arkansas, Kentucky, Louisiana, South Carolina, Virginia), Midwest (Illinois, Indiana, Michigan, Minnesota, Missouri, Ohio, Wisconsin), Prairies (Montana, North Dakota), Southwest (Arizona), and Far West (Alaska, California, Oregon).

A summary of responses to each of the questions posed to the State agencies is provided in the following 10 paragraphs.

1. Considering all of the environmental (physical and biological) factors that can affect fish populations in public waters, including consumption by commercial and sport anglers, what is the relative role or importance of DCCO predation? None of the 13 States responding to this question was able to provide satisfactory information about the relative role of DCCO's in aquatic ecosystems. Eight States (Arkansas, Indiana, Kentucky, Louisiana, Minnesota, New Hampshire, Pennsylvania, South Carolina) reported a lack of documented evidence that DCCO predation was currently a significant factor limiting sport fish populations. Four States provided anecdotal evidence about the possible role of DCCO's. Oregon reported that elimination of human harvest of coho salmon for 3 years did not result in a recovery of the population, suggesting that other factors (possibly including DCCO predation) are currently more important in controlling coho populations. North Dakota believed that the relative impacts of DCCO's on prairie lakes and reservoirs managed for sport fish were "significant." Maine thought that DCCO predation on newly stocked salmonids was "probably high" in some situations. And Arizona noted the beginnings of a problem at put-and-take trout lakes receiving heavy recreational fishing, where the number of DCCO's has increased over the past 10 years from none to about 40 birds/day. Michigan noted that DCCO predation was responsible for about one-fifth of the total annual mortality of yellow perch at one location (see Diana et al. 1997).

2. Is there any documented evidence that increased DCCO populations have depleted the supply of fish available to sport anglers? Twenty-one States responded to this question, and most (15) reported a lack of evidence that DCCO's have depleted the supply of fish available to sport anglers. Four of these States qualified their responses. For example,

Arkansas was concerned that predation on forage fish could deplete the prey base for largemouth bass and crappie. California suggested that DCCO predation could affect fish populations at hatcheries. Montana noted that there may be localized situations in which fisheries are impacted by concentrations of DCCO's, and Michigan indicated that DCCO's had certainly caused some reductions—but not depletions—in the numbers of some species available to sport anglers. Six States reported impacts to sport fish (but not necessarily depletion of supply of fish available to sport anglers) of a largely anecdotal nature: Maine reported documented predation on Atlantic salmon (*Salmo salar*). Arkansas noted a decrease in "return-to-creel" harvest indices. Alabama noted that unsuccessful attempts by DCCO's to catch bluegills (*Lepomis macrochirus*) severely wounded most of these fish in a pond. New Hampshire reported "seemingly strong circumstantial evidence" of predation on stocked brown trout (*Salmo trutta*). North Dakota indicated that "problems of DCCO predation are compounded during migrations that coincide with State stocking efforts, with DCCOs targeting spring-stocked trout, which take 1–3 weeks to acclimate to the new environment." And Virginia thought that increased DCCO populations have "undoubtedly" had some local impacts on fisheries.

3. Is there any documented evidence that increased DCCO populations have affected local economies associated with the sport fishing or tourism industries? None of the 12 responding States reported any documented evidence that DCCO's had affected local economies associated with the sport fishing or tourism industry. Oregon noted that "we can document the economic effect of decreased salmon populations through closure of commercial fisheries and formerly popular sport charter fisheries, and declining sales of salmon harvest tags, but we believe that DCCO predation is only one of a number of causative factors which in total are responsible." North Dakota replied that potential losses to DCCO's constituted "an economic drain" to local communities and sport anglers, but the State did not provide details.

4. Is there any reason to believe that a widespread DCCO control program would significantly increase the supply of fish available to sport anglers? Of the 14 States answering this question, eight (Arizona, California, Connecticut, Kentucky, Louisiana, Michigan, Minnesota, Pennsylvania) responded that a widespread DCCO control program was not justified, because there is no evidence that it would increase the supply of fish available to sport anglers. A variety of responses was received from the remaining six States. Two (Maine and South Carolina) indicated that widespread control might be appropriate for protecting newly stocked hatchery fish. North Dakota thought that widespread DCCO control “would significantly increase game fish” populations. Arkansas suggested that decreasing the DCCO population “might possibly” increase the amount of forage available to sport fish. Oregon replied that it did not have enough information to judge whether widespread control would be an appropriate approach. And Montana reported that any potential solutions, including widespread control, should be carefully evaluated before being implemented.

5. Is there any reason to believe that localized DCCO control programs would significantly increase the supply of fish available to sport anglers? Replies to this question generally mirrored those received in response to the previous question. Of the 14 States responding, 8 (Connecticut, Illinois, Kentucky, Louisiana, Michigan, Minnesota, Oregon, Pennsylvania) implied that they did not support localized population control because of uncertainties about its effects on sport fish populations. The remaining six States submitted a variety of responses. Three (Maine, New Hampshire, South Carolina) suggested that localized control might be necessary to protect newly stocked hatchery fish. North Dakota believed that local DCCO control “would significantly increase game fish” populations. Arkansas suggested that DCCO control “might possibly” increase the amount of forage available to sport fish. Arizona indicated that local control “may” be necessary if data are collected that indicate local impacts.

6. Are there any circumstances under which your agency would support or endorse DCCO control programs on public lands or waters? This question elicited a wide variety of responses from the 18 States that replied:

Reduce sport fish impacts (when documented)—four States (Arkansas, Louisiana, Michigan, North Dakota);
Control disease outbreaks—three (Kentucky, Minnesota, Montana);
Protect newly stocked hatchery fish—two (Maine and New Hampshire);
Protect sensitive colonial waterbird populations—two (Connecticut and Ohio);
Reduce aquaculture impacts—two (Missouri and Pennsylvania);
Not specified or none—two (Illinois and South Carolina);
Don’t know—two (Arizona and Oregon); and
Protect endangered or threatened fin fish—one (California).

7. Assuming that a DCCO control program was judged to be biologically sound and socially acceptable, could the costs be justified in an era of Federal and State budget cutting (i.e., how would you rank DCCO control relative to the other resource management funding needs of your agency)? Of the 13 States responding to this question, only 4 (Arizona, Maine, Ohio, Oregon) ranked DCCO control as a high or fairly high priority relative to other resource management funding needs of the agency. Maine and Oregon suggested that the expenses of DCCO control could be justified on the basis of the value of the fish (e.g., hatchery-reared fish, anadromous salmonids) affected by DCCO predation. Arizona replied that sport fish restoration (Dingell–Johnson) funds could be used to pay for the costs of DCCO control. Five of the States responding to this question (Arkansas, Connecticut, North Dakota, Pennsylvania, South Carolina) implied that the costs of cormorant control might be justified in some instances

but did not rank DCCO control relative to other funding needs of the agency. Finally, four States (Kentucky, Louisiana, Michigan, Minnesota) considered DCCO control to be a fairly low or very low priority. Michigan commented further that

Even if DCCOs were shown to have a major impact on perch populations, it is doubtful that a control program would be socially acceptable. It would be like advocating the control of hawk and owl populations so more pheasants are put in the hunter's bag!

8. Would removing the DCCO from the protection of the Migratory Bird Treaty Act (MBTA), a measure favored by some sport anglers, be beneficial or detrimental in helping to resolve the DCCO–fish depredation issue? Of the 14 States responding to this question, a majority of 9 (Alaska, Arizona, Connecticut, Kentucky, Louisiana, Michigan, Minnesota, Missouri, Pennsylvania) did not favor removal of the DCCO from the protection of the MBTA. Selected comments from this group of States variously described the proposed action as “inconsistent given the best scientific information currently available” on the impacts of DCCO’s on sport fisheries (Alaska), “unwise” (Pennsylvania), “a bad precedent” (Michigan), “not . . . prudent” (Missouri), and “send[ing the wrong] message to anglers” (Minnesota). Five States (Arkansas, Maine, North Dakota, Oregon, South Carolina) implied that removal of the DCCO from protection of the MBTA “might be helpful” if it was determined that DCCO predation was a significant limiting factor for sport fish populations.

9. What is the single most beneficial and cost-effective action the Service could take to resolve this controversy? The 16 responses reflected a diversity of opinions. Five States (Alaska, Michigan, Minnesota, Montana, Oregon) indicated the need for additional site-specific research to assess the impacts of DCCO’s on sport-fish populations and their role in the transmission of fish diseases. Three States (Kentucky, North Dakota, South Carolina) believed that additional management authority should be given to individual States. Two States (Arizona and Louisiana) thought the FWS should be willing to issue additional site-specific depredation permits. Two States (Minnesota and Missouri) suggested additional outreach and education efforts. One (Maine) advocated local control to protect newly stocked hatchery fish, and another (Pennsylvania) recommended issuing limited take permits to aquaculture facilities. Two States (Arkansas and Virginia) advocated proactive DCCO population control. Addressing the issue of population control, Indiana provided the following warning:

In the history of terrestrial game management, predatory control was often attempted to produce more game for hunter harvest; in all but a few, restricted, circumstances this did not prove effective.

10. Has your agency developed any educational or informational materials on DCCOs and the problems they cause? None of the 11 States responding to this question had developed any educational or informational materials on DCCO’s. DCCO factsheets developed by two Federal entities—the Canadian Wildlife Service (Weseloh and Collier 1996) and the FWS (U.S. Fish and Wildlife Service 1995)—have been posted on the Internet.

Provisional Strategies for Reducing DCCO–Human Conflicts

In light of growing concerns (whether imagined or reality based) about DCCO's, the FWS is currently formulating a policy to address DCCO–human conflicts. Because of complex and intertwined biological, economic, political, and social ramifications, resolution of this conflict remains extremely dynamic. It is quite likely that many of the strategies being considered at the time of the symposium and outlined here will be obsolete by the time this paper is published. The range of activities that one could consider for addressing DCCO management problems is provided for discussion and illustrative purposes. One or several of these activities could be applied and adapted depending on local circumstances.

We believe that every effort should be made to base bird management decisions on biological data. Therefore, we strongly support monitoring and research that will allow science-based decisions about DCCO control. We believe that it is imperative for DCCO management activities to be done in close cooperation and coordination with the U.S. Department of Agriculture's (USDA) Wildlife Services (formerly Animal Damage Control) program, State and Provincial wildlife agencies, and the Canadian Wildlife Service. We also recognize that education and outreach are essential components of an integrated DCCO management program.

Sport Fisheries Impacts

On the basis of a review of the best available science, we recognize that DCCO's generally have only minor direct impacts on sport fish populations, for they are just one of myriad biotic and abiotic regulatory factors, including water quality, aquatic habitat, natural predation, and angler take. Therefore, we do not believe that a large-scale reduction of DCCO populations to benefit sport-fish populations is biologically warranted. However, we also recognize that there may be highly localized situations in which DCCO's can have signifi-

cant impacts on sport-fish populations. These are generally situations in which sport fish are concentrated in extremely high densities, often by human activities (e.g., massive releases of hatchery-reared fingerlings, intensively managed put-and-take fisheries, and temporary congregations of fish at nearshore spawning sites). The FWS currently does not issue DCCO depredation permits to benefit sport-fish populations in public waters but is exploring potential options that could be used to deal on a case-by-case basis with localized DCCO predation when it has been proven to be a significant problem. Two possible options include (1) modification of release practices for hatchery-reared fish to reduce their vulnerability to DCCO predation, and (2) harassment of depredating birds. Federal law does not prohibit (but State and local laws might) the harassment of depredating birds, provided the activity does not cause the death of birds or eggs.

Aquaculture Impacts

We recognize that DCCO's can have severe economic impacts on private aquaculture producers. These impacts have been best documented in the catfish industry in the mid-South, where losses due to DCCO depredations have been variously estimated at 3 to 7 percent of the catfish standing crop each year. The FWS has issued depredation permits since the late 1980's to aquaculturists who are able to demonstrate that they are suffering economic losses and that nonlethal techniques have proven ineffective (Trapp et al. 1995, Coon et al. 1996). The FWS works closely with the Wildlife Services program of USDA's Animal and Plant Health Inspection Service, which is responsible for documenting economic impacts and for developing nonlethal alternatives. A proposal to establish a DCCO depredation order (U.S. Fish and Wildlife Service 1997) to help alleviate depredations on aquaculture stocks was implemented in March 1998 (U.S. Fish and Wildlife Service 1998). This order allows DCCO's to be taken in certain States without a permit when causing depredation problems at commercial aquaculture facilities.

We believe that the aquaculture industry shares responsibility for alleviating this problem. The industry should be aggressively promoting the design of new facilities (and the retrofitting of old ones where economically feasible) that exclude or repel DCCO's and other fish-eating birds from the facilities. We anticipate that USDA's Wildlife Services program will continue to research nonlethal means for reducing aquaculture depredation problems.

Impacts on Other Colonial Waterbirds

We recognize that DCCO's can affect other colonial waterbirds at mixed breeding colonies, both directly (by physical displacement) and indirectly (by altering the vegetation). Only if there were convincing evidence that a Federal- or State-listed endangered or threatened bird species, or a regionally significant population, was being harmed by the actions of the DCCO's could we recommend issuing a permit for DCCO control. Such control could be difficult in mixed colonies because of the potential disturbance to other species and could be most effective if done before the comorants became well established.

Vegetation Impacts

We recognize that DCCO's can drastically alter the vegetation of nesting islands and roost sites, affecting the ecological balance of a site and possibly lowering property, recreational, or esthetic values. Our recommended action could depend on whether the affected vegetation was located on private or public land. On private land, we could recommend issuing a depredation permit if the landowner could prove that the actions of the DCCO's were lowering their property values or reducing their use of the property for esthetic or recreational purposes. On public land, we could recommend issuing a depredation permit only if there was convincing evidence that Federal- or State-listed endangered or threatened plant species, or rare or declining plant communities, were being harmed by the actions of the DCCO's.

Harassment of birds is a potential option for dealing with this problem. Provided the activity does not cause the death of birds or eggs, Federal law does not prohibit the harassment of depredating birds (but State and local laws might).

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